Laptop applies new concepts in computer-based learning to flight deck automation training

A NASA research project is exploring the feasibility and effectiveness of using portable computers, higher-fidelity equipment emulation and interactive multimedia to help pilots learn about modern flight deck automation.

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As the demand for flight deck automation training grows and training budgets get smaller, there is increasing interest in a new breed of flight instructor: one that runs on a personal computer.

Although not a new idea, older generation computer-based training systems met with limited success for a number of reasons. Most notably, the early systems failed to offer learners the interactive experience needed to keep them interested in their training exercises, answer their many questions and hone their skills in high-fidelity situations. However, a new age is upon us — one that offers in a small package the computing power that once usurped a large room.

In stride with computer hardware breakthroughs, instructional software technology has progressed far beyond the question-and-answer programmes of earlier software. Techniques are now available that allow learning systems to contain their own working representations of the very skills and knowledge that they are designed to impart to students, opening the doors to a new kind of communication between the computer and human learner. Compact disc read-only memory (CD-ROM) publishing, and the construction of channels for worldwide information exchange, offer the makings of a revolution in the way professionals learn the skills that earn their keep.

Prototype FMS training system

A prototype of a next-generation computer-based training system designed to help pilots make the transition to the modern glass cockpit aircraft has been developed at the U.S. National Aeronautics and Space Administration (NASA). Running on a Macintosh laptop computer, the device is the heart of a NASA research project designed to explore the feasibility and effectiveness of using portable computers, higher fidelity equipment emulation and interactive multimedia to help pilots learn about modern flight deck automation. The laptop training system combines and develops recent advances in computing technology, the human learning process and, most importantly, the combination of these advances.

A key feature of the laptop training system is that it contains a moderate to high fidelity software emulation of the flight management system (FMS) found in the Boeing 737-300. The training system includes software emulations of important hardware devices such as the control display unit (CDU), the mode control panel (MCP), a flight mode annunciator (FMA) and two electronic map displays that graphically show the lateral and vertical components of the planned flight route. The pilot can use the mouse to activate the dials, windows, pages and lines offered by these devices in roughly the same manner as a pilot would interact with the equipment on the flight deck.

The five devices are coupled with another software emulation of the flight management computer (FMC), which builds the flight paths using navigation and performance databases. Care was taken to ensure that the targets generated by the FMC emulation are reasonably close to, but not always exactly the same, as those generated by the actual equipment. The laptop FMS training system includes a navigation database containing all fixes and airways in the continental United States along with the departure and arrival procedures for roughly 25 major U.S. airports.

A version of the laptop FMS training system will be employed at the training centre of a major U.S. airline later this year. *Photo by Stephen Casner*

Concepts and procedures

A central aim of the NASA project is to depart from the "procedures only" method of training in which pilots are simply told or shown what to do. Research experience with automation suggests that the twists and turns of a modern autoflight system

design are too numerous to allow teaching or promoting a simple understanding of how the system works. The complexity arises from the fact that flight management systems respond in different ways to the same pilot input, depending on which system modes may be in operation. For example, the technique of pushing the "speed" button on the mode control panel can often be used to comply with a speed clearance. Speed mode works by using the throttles to control the speed. However, when another mode is engaged that uses throttles to control the flight path, e.g. "level change," the speed mode becomes deactivated since the throttles are unable to control both speed and flight path at the same time. This simple example demonstrates that rote procedures such as "use speed mode to control speed" are not adequate. The pilot needs to know more about how the autoflight modes work together as a system.

To accomplish a more conceptual presentation of FMS procedures, the laptop training system uses coordinated text, diagrams, video, soundtracks, demonstrations and interactive practice to provide an overview of how modern flight management systems accomplish their goals, describing their strategies and priorities and showing how the pilot can use the system to perform flight manoeuvres. For example, before teaching the trainee the sequences of actions required to execute a descent with minimum consumption of fuel, the laptop trainer provides an overview of the basics of an economy descent. This overview explains how the automation system aims to exchange the energy stored in the aircraft at cruise altitude for forward progress in a descent at idle thrust in an effort to save fuel. This explanation includes the factors that influence the automation system's choice of top of descent point (e.g. gross weight and descent speed), and the environmental factors influencing the outcome of the descent (e.g. winds aloft and barometric pressure). Finally, the trainee is shown how to execute the descent and is also shown the importance of keeping the system informed about any known changes in environmental conditions that can affect the energy management process.

The laptop training system contains an encyclopedia of automation-related materials that have been authored by several pilots at NASA. These materials range from interactive demonstrations and video clips to "war" stories: informal descriptions of puzzling encounters with automation, and tips for success. We are particularly interested in exploring the use of the laptop trainer as a medium for the collection and dissemination of this type of information. For the time being, we have established a Worldwide Web page that will serve as an information centre.[1]

Line-oriented practice

A third feature of the laptop FMS training system is its emphasis on practice in specific line-oriented flight training (LOFT) scenarios. The training system contains a collection of brief LOFT exercises that challenge the trainee with a variety of flight scenarios. The mini-LOFTs included in the laptop's multimedia encyclopedia were collected during many jump-seat observations and from discussions with airline pilots.

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Centring training around specific airport procedures and en-route modifications is motivated by two reasons. First, our understanding of the psychological process of learning suggests that performance skill comes from extended practice performing the same skill that a trainee will be asked to perform on the job. A second reason is the gradual disappearance of the flight engineer position. In the past, new pilots often spent several years in the second officer's seat learning the details of the airspace system. This experience provided them with a familiarity that allowed them to concentrate on other duties when they became first officers. This form of on-the-job training is now disappearing as automation assumes the role of systems' supervisor.

Intelligent help

A fourth important feature of the laptop training system is that it contains more detailed representations of the skills that the pilot trainee is being asked to master. When combined with the FMS emulation, these representations allow the laptop trainer to make detailed inspections of the actions of the trainee pilot, the state of the FMS, and the flight manoeuvre being attempted. The laptop training system can actively evaluate what the student is doing when working through an exercise and generate specific feedback messages about how to proceed. For example, when a student is attempting a manoeuvre to intercept an inbound leg, the laptop can compare the state of the system as the exercise progresses to its own internal representation of how the system must be configured in order to accomplish the manoeuvre. The laptop's representation of a correct intercept manoeuvre includes the actions of dialling a proper intercept course and arming lateral navigation (L/NAV) to capture it. Should either of these steps be missing from the record of actions taken by the trainee, the laptop can intervene with an advisory explaining how to improve the situation.

Portable equipment

Providing higher equipment fidelity on a portable computer seems to suggest novel training opportunities. For example, laptops could be issued to pilots when they arrive for training, and could be used when studying training manuals or when preparing for each day's simulator session. Completing a few reviews of each day's flight manoeuvres might help simulator sessions proceed more smoothly. Alternatively, check airmen might use a tool like the laptop to give quick proficiency checks to trainees before entering the flight simulator.

Aside from its use during initial training, we are also interested in promoting the continuous use of tools like the laptop FMS training system following completion of company training. Training programmes typically aim to provide pilots with only the basics of automation: how to pre-flight the aircraft, install a route and programme the important en-route modifications such as holds and interceptions. Systems such as the laptop might be used to support on-the-line learning and help pilots prepare for trips to unfamiliar airports.

Deployment of the FMS trainer

A beta version of the laptop training system developed by NASA will be deployed at the training centre of a major U.S. air carrier sometime this year. The initial phase of this deployment will be aimed at exploring ways in which the tool might be integrated into the company's training programme. Later phases will aim at understanding the effectiveness of the training tool in particular roles. We are also making arrangements with several university aeronautics departments to place copies of the laptop training system in computer learning laboratories. □

1. The World Wide Web site address is http://olias.arc.nasa.gov/projects/computer-based-training/the_box.html

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